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GIPSY-MOTH LARVÆ AS AGENTS IN THE DISSEMINATION OF THE WHITE-PINE BLISTER-RUST[1]

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INTRODUCTION

Very little has been done to correlate the widespread distribution of the white-pine blister-rust, caused by *Cronartium ribicola* Fischer, with factors governing the dissemination of the spores of the causal organism. The early occurrence of telia on leaves of currant and gooseberry plants (*Ribes* spp.) in localities distant from known infections on pines (*Pinus* spp.), together with the absence of definite knowledge of instances of overwintering on the former hosts, is suggestive of distant seasonal spread of the disease by æciospores from pines.

Larvæ of the gipsy moth (*Porthetria dispar* L.) feed on the Peridermium stage of *Cronartium ribicola* and carry thousands of æciospores on their bodies. As Collins[2] found that larvæ of the gipsy moth are blown as far as 20 miles, these insects are a potential agent in distant spread of the blister-rust. The gipsy moth is distributed over a large portion of the white-pine region of New England.

GIPSY-MOTH INFESTATION ON DISEASED PINE

In the fall of 1916 a stand of white pine covering an area of from 5 to 7 acres at Kittery Point, Maine, was found to be severely infected with *Cronartium ribicola*. This growth ranged from young seedlings to mature trees 80 feet tall and random ¼-acre plots in this area showed 65 to 100 per cent of the trees to be diseased. The number of infections on individual trees ranged from 1 to more than 300, and it was estimated that there were 75,000 to 100,000 separate infections in trees on this area.

In the infected plot gipsy-moth-egg clusters were found in varying abundance on limbs and stems of pines of all sizes, and were located from near the ground to the tops of the largest trees. In a number of cases egg clusters were present on the diseased bark, and in one instance four were located on a single canker.

[1] The writers are indebted to Mr. A. F. Burgess, of the Office of Gipsy Moth and Brown-tail Moth Investigations, Bureau of Entomology, for helpful suggestions. Further work is being carried on in cooperation with the above office.

[2] Collins, C. W. Dispersion of gipsy moth larvæ by the wind. U. S. Dept. Agr. Bul. 273, 23 p., 7 pl. 1915. Bibliography, p. 22–23.

——— Methods used in determining wind dispersion of the gipsy moth and some other insects. *In* Jour. Econ. Ent., v. 10, no. 1, p. 170–176, 2 pl. 1917.

On May 25, 1917, large numbers of gipsy-moth larvæ were found in and around ruptured blisters, and several days later some of the blisters where the presence of larvæ had been previously noted were empty, and spore production was apparently arrested. Subsequent observation on these blisters showed that no further spore production took place, while on the same cankers blisters which were artificially protected from larvæ continued to produce spores in abundance until June 25. To determine the rate of blister destruction on June 9 a number of larvæ were placed on a twig infection which had 38 sporulating pustules. Many of the larvæ crawled away or dropped off, but a sufficient number remained to destroy the fruiting layer in practically every blister by noon of the following day, with the result that no subsequent spore production took place.

Cessation of spore production in injured blisters was caused by the destruction of fruiting hyphæ. Usually the spores and hyphæ were eaten away first and then the larvæ very often ate through the base of the fruiting layer to a depth of several millimeters. Apparently, after blisters no longer furnished suitable food for the larvæ, they began feeding on the areas of the yellowish, discolored, infected bark outside the fruiting region and in some cases a large per cent of the outer bark of next year's sporulating zone was destroyed. Careful observations on many larva-infested cankers showed that spore production was prematurely arrested in 25 to 100 per cent of the pustules, the percentage usually averaging highest on small twigs.

SPORES ON LARVÆ

Larvæ working in blisters collected so many æciospores on their hairy bodies that they appeared nearly the color of spores in mass. On different dates larvæ were taken from blisters and placed in separate capsules, precautions being taken against including spores not on the bodies. These were taken into the temporary laboratory and spore counts made of the bodies and the alimentary tracts. Spores for counting were removed from larvæ by washing the bodies in series of water, and alcohol mounts on slides followed by final examinations to assure thoroughness in the method used. This procedure proved quite effective, and, where carried through 5 to 10 washings, practically all spores were removed from the outside of the bodies. Counts were made on the spores adhering to the inside of the capsule and added to the total found in the washings. After bodies of the larvæ had been thoroughly washed, they were dissected and counts made of spores in the alimentary tracts. On May 26, June 4, and June 11 fifteen small larvæ were collected. Spore counts on the bodies of these 15 gave a minimum of 1,120, a maximum of 28,320, and an average of 18,100. Counts of spores in the alimentary tract gave a minimum of 1,740, a maximum of 48,570, and an average of 26,022

To determine the approximate amount of spore material passed through the alimentary tract, 20 larvæ were placed on fresh cankers in a feeding tray. After they were settled and had fed normally for several hours, a sheet of paper was placed under the cankers for the collection of pellets. A total of 423 pellets were dropped within a period of 13 hours. Counts of the spores in these pellets gave from 3,960 to 12,450, with an average of 8,160, which is at the rate of 318,616 spores excreted per day per larva.

Germination tests made of the spores on the bodies of larvæ collected on cankers gave positive results, and approximately the same percentage of germination was observed as on spores taken directly from these cankers. Germination tests of spores in pellets have given very poor results; in only one case did several spores germinate. In many cases spores taken directly from these cankers also failed to germinate in laboratory tests.

WIND DISPERSION OF LARVÆ AS A FACTOR IN BLISTER-RUST SPREAD

At Kittery Point, Me., æciospores were produced from April 29 to July 1, with maximum spore production from May 10 to 25. Collins[1] gives the hatching period for gipsy moth larvæ in this section for 1912, 1913, and 1914 as May 1 to 23, April 29 to May 14, and May 11 to 28, respectively. The season of 1917 was approximately one week later than usual. The period of wind dispersion of larvæ is given as ranging from 18 to 30 days, starting one to two weeks after the first caterpillars hatched. Observations by the writers showed varying numbers of larvæ feeding on blisters from May 25 to June 25.

Collins[2] working with wind dispersion of larvæ of the gipsy moth over a series of several years showed that they were carried in wind currents to distances as great as 20 miles. The same author states that approximately 50 per cent of the larvæ caught at distances of 6 miles or less had fed previously.

The writers, using fly-paper traps, placed 10 to 30 feet from the nearest pine infection, and so arranged as to exclude larvæ that may have reached the trap by crawling, caught 75 small larvæ. Four of these caterpillars had, respectively, 35, 105, 185, and 2,180 æciospores on their bodies, which establishes the fact of local wind dispersion of æciospore-bearing gipsy-moth larvæ. That spores carried on bodies of larvæ may remain viable for a considerable length of time is borne out in viability tests under laboratory conditions, wherein æciospores germinated after remaining in vials for a period of two months.

Examination of wild and cultivated species of Ribes at various points throughout Kittery Township showed an abundance of gipsy-moth larvæ feeding on the foliage, and in many cases they were observed crawling on the under surfaces of leaves. Quite a number of the larva-

[1] COLLINS, C. W. 1915. Op. cit. [2] COLLINS, C. W. 1917. Op. cit.

infested plants showed areas producing uredospores, and in four instances the only leaves showing blister-rust infections were those which had been injured by insects.

Sixty larvæ collected on species of Ribes were examined for æciospores. Of these one larva collected on June 14 on the under surface of a wild gooseberry plant showed 280 æciospores and 520 uredospores on its body. The gooseberry plant was heavily infected with blister-rust, being located only 20 feet from pine infections. Germination tests of the spores from this larva gave two germinating æciospores and many germinating uredospores, thus bearing out the fact that gipsy-moth larvæ do carry viable spores to *Ribes* spp. and also showing the part which insects may play in local distribution of the disease by uredospores.

PRACTICAL IMPORTANCE

The facts given in regard to the gipsy-moth larvæ show that these insects are certainly a factor in the spread of the blister-rust locally from pines to *Ribes* spp. Their habit of feeding and crawling over the lower leaf surface, where the stomata are located, gives the spores borne on their bodies a good opportunity for causing infection. The probability of the spread of blister-rust from pines to distant *Ribes* spp. is undoubted, since Collins' work shows that the gipsy-moth larvæ are blown by winds of varying intensity for distances of 20 miles. Though wind is considered to be the most important factor in æciospore dissemination, gipsy-moth larvæ undoubtedly play an important part. Other insects have been collected from infected pines with thousands of æciospores on their bodies, but these insects were not present in sufficient numbers to make them of importance in comparison with the number of gipsy-moth larvæ present.

SUMMARY

(1) The period of hatching and of wind dissemination of gipsy-moth larvæ came within the period of spore production of the blister-rust on pines.

(2) Larvæ fed abundantly on spores and injured the fruiting layer of the pustules so that further spore production was arrested.

(3) Larvæ from blister-rust cankers had thousands of viable spores on their bodies. A small percentage of the larvæ collected from fly paper and from species of Ribes near infected pines showed æciospores on their bodies.

(4) Gipsy-moth larvæ were found feeding on leaves of *Ribes* spp., and in some cases the only infected leaves on plants of this genus were those showing insect injury.

(5) The Bureau of Entomology has shown that these larvæ are blown by the wind up to a distance of 20 miles. Within this distance the larvæ are potential agents in the spread of the white-pine blister-rust (within the area infested by the gipsy moth).